CURRENT RESEARCH TRENDS IN CIVIL ENGINEERING

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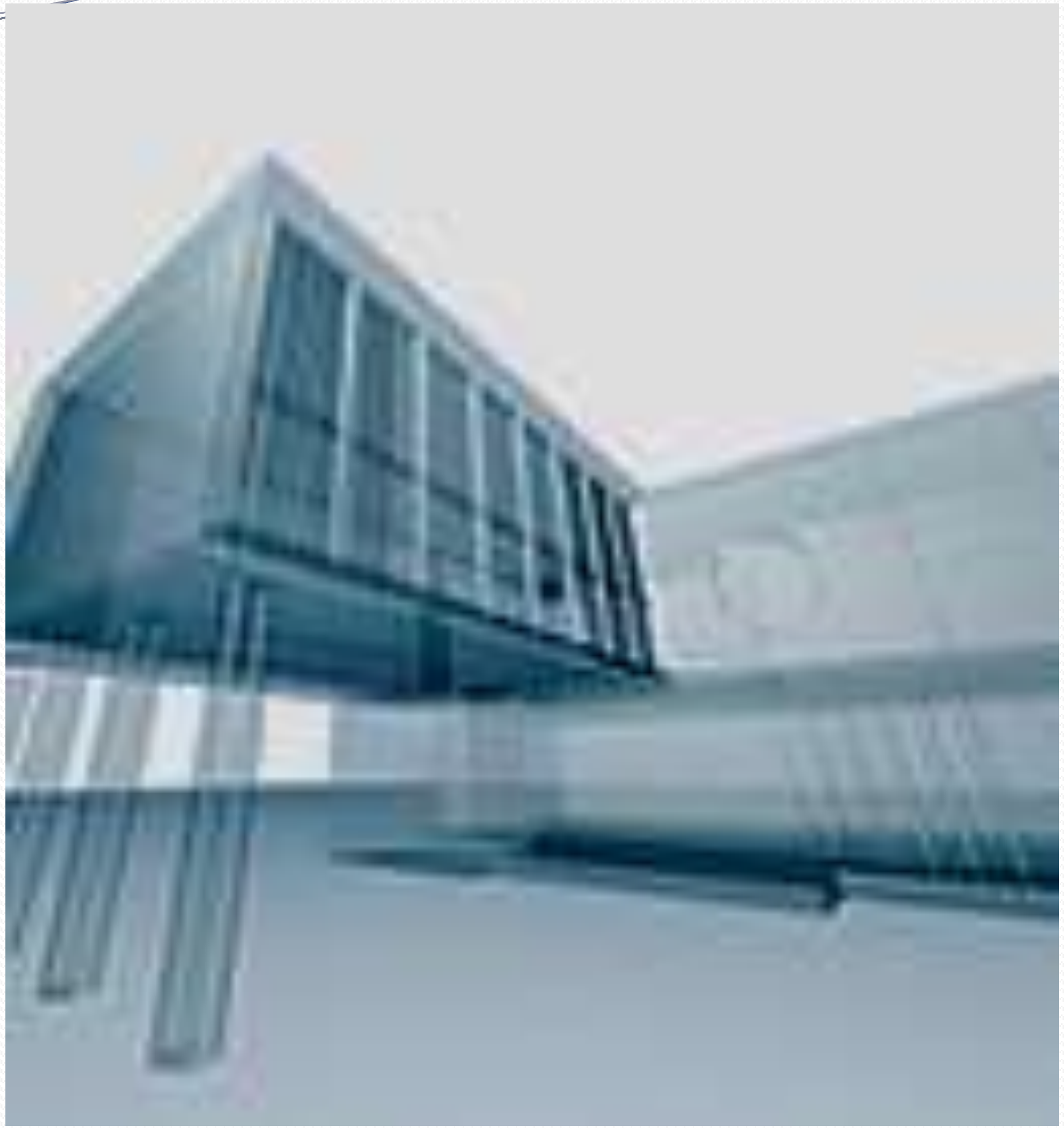
TOP 8 UPCOMING DEVELOPMENTS AND TRENDS IN CIVIL ENGINEERING

1. Virtual Reality (VR) and Augmented Reality (AR)

Virtual Reality (VR) and Augmented Reality (AR)

- It's applicability in Civil and Construction Industry is gaining immense popularity.
- VR and AR are forms of immersive media to visualize the end results
- It's being used by both end users and the civil engineering project teams
- Virtual Reality is a user experience that was once possible only in science fiction
- Stakeholders and designers can benefit from the interactive and immersive experience
- AR interweaves real-world and graphics to give field personnel and civil engineers useful information such as health and safety warnings, productivity statistics, design specifications, etc., making their job on field easy.
- This is just the beginning, and the applications of VR and AR technologies are expected to broaden



2. Building Information Modelling (BIM)

Building Information Modeling (BIM)

- Large-scale utilization of the Cloud technology and Big Data
- Engineers can now create virtual models of their designs through intelligent 3D modeling process
- This futuristic technology can speed up the time taken to turn building drawings into reality.
- Construction of bridges, electricity networks, and superstructures can gain momentum with workable virtual models of the design
- BIM and 3D modeling provide engineers a chance to visualize completed designs

3. Demand for Sustainable Designs

Demand for Sustainable Designs

- **Sustainable design is the most significant civil engineering trends**
- **Highly supported by global organizations and even the government**
- **Greater demand for smart materials, intelligent electrical grids, smart buildings**
- **Innovate sustainable designs that are forward-looking**
- **Key areas of focus are zero-energy housing and better utilization of captured energy.**
- **Smart use of space in housing which can ease the congestion**

4. Drones Will Remain a Mainstay

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- **Sales of drones is likely to exceed $12 billion by 2021**
- **Drones are steadily making its presence felt in civil engineering industry, greatly influencing the design, development, and surveying of civil engineering projects**
- **Drones are instrumental in carrying out safety inspections along with progress reporting**
- **Drones effortlessly access hazardous sections of the construction and collect data from large areas**
- **This technology has allowed surveyors to get the job done without risking life and limb.**
- **Regulation of drone technology is debated due to its fast-paced evolution and its affordability**

5. Advanced Building Materials Will Shape the Civil Engineering Designs of the Future

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- Advanced materials with shifting properties that adapt to external conditions
- From cement composite, advanced steel, and self-healing concrete, to fiber-reinforced polymer composites, technology is transforming the materials being used in construction.
- 4D-printed structures that transform according to the shifting environmental conditions
- Buildings in major cities around the world are coated with photo catalytic titanium dioxide to combat pollutants in the air
- In the long-term, it will mitigate human-induced environmental hazards
- The civil engineering design of the future is all about advanced materials that are largely focused on reducing carbon footprints and harnessing the energy that our planet has to offer

6. Internet of Things (IoT) Will be Leveraged to Engineer Smart Cities

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- IoT leverages sensors and network connectivity to allow communication between the interconnected sensors
- IoT will play a leading role in monitoring the health of urban structures
- It will be capable of recording data such as variations in concrete humidity, vibrations, chloride content and even abnormal deformations.
- IoT will play a leading role in monitoring water quality. Air quality. Traffic management of urban areas
- It is one of the latest upcoming trends that will give rise to smart cities and improve the quality of life of its inhabitants.

7. 3D Printing Is Expected to Have the Most Significant Impact in Civil Engineering

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- Year 2017 witnessed a surge in the demand for 3D printing across various domains
- Year 2018, this revolution has reached construction and civil engineering industry in a big way
- 3D printing can turn engineering designs into scale models or even real components
- This technology, currently in the advanced stage is ready to take on more complex civil engineering challenges involving full-sized homes and bridges
- This is one of the most exciting upcoming trends in civil engineering

8. Robots May Take Up Mundane Civil Engineering Tasks

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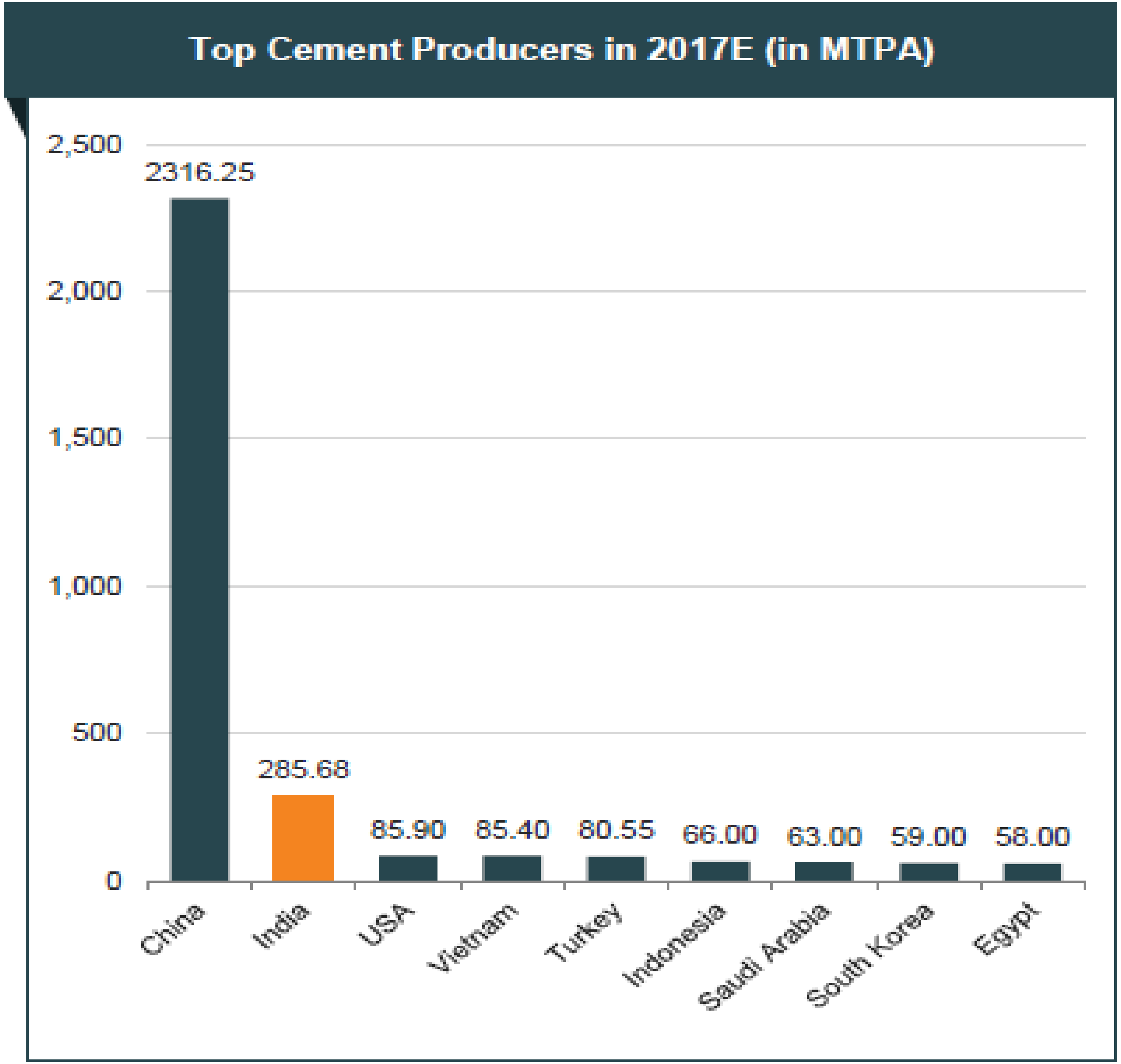
- **Robots in the construction industry are taking over tasks that are hazardous to humans**
- **It not only improves worker safety and productivity but also saves costs in the long run**
- **Civil engineering industry tasted success with many iterations of bricklaying robots**
- **However, the immediate challenge with Robotics is its initial cost, feasibility of mass application, and reliability.**
- **We can expect to see robots taking over the mundane tasks in construction and civil engineering in the future.**

Construction Materials

Cement Concrete and Bituminous Concrete.

The generic composition of typical PCC is as follows:

- **Cementitious materials (portland cement, fly ash, slag)—10 to 14 percent by volume.**
- **Aggregate (coarse, intermediate, fine)—62 to 68 percent by volume.**
- **Water—14 to 18 percent by volume.**
- **Air—4 to 8 percent by volume.**
- **Admixtures—very small amounts.**


Top Cement Producers in 2017E (in MTPA)
2,500
2,000
1,500
1,000
500
0
2316.25
285.68
85.90
85.40
80.55
66.00
63.00
59.00
58.00
China
India
USA
Vietnam
Turkey
Indonesia
Saudi Arabia
South Korea
Egypt

Bituminous Concrete

The generic composition of typical Bituminous Concrete is as follows:

- **Bituminous binder—6 to 8 percent by volume.**
- **Aggregate (graded)—85 to 90 percent by volume.**
- **Filler material—2 to 3 percent by volume.**
- **Air—2 to 4 percent by volume.**

India has the world's second largest road network after the United States of America, with a road infrastructure of over 47,000 km.

The Indian bitumen market that is currently around 5 million tonnes is expected to grow in the future due to the Governments proposed construction projects to upgrade the road network

NEED OF THE DAY

SUSTAINABILITY AND AVAILABILITY OF SOUND MATERIALS

- Supply of acceptable quality aggregates is very limited
- The production of portland cement is very energy intensive and also accounts for high carbon dioxide (CO_2) emissions.
- In future the cost of cement production may rise to meet environmental regulations.
- The availability of bituminous binders is dependent on the supply of oil and oil industry
- Cost of construction materials continues to increase every year
- There is a need for advanced materials that are cheaper, better performing, and less damaging to the environment.

BASIC REQUIREMENTS OF ADVANCED HIGH-PERFORMANCE MATERIALS

The needs for seeking advanced construction materials include:

- Reduced costs—get structures constructed or rehabilitated for a given constrained budget.
- Conservation of resources—create sustainable solutions to minimize impact on the environment.
- Reduced ecological footprint.
- Extended service life.
- Optimized use of locally available materials.
- Achieving environmental benefits—reduced carbon footprint
- Reduced work zone–related delays and safety concerns—reduce the potential for early failures

The currently used materials for Cement Concrete and Bituminous Concrete construction can be classified as follows:

1. **Natural (Raw) Materials.**
    a. **Aggregates.**
    b. **Lake asphalt.**
    c. **Natural resins.**

2. Manufactured (Processed) Materials.

- **a. Metallic materials (steel, aluminum, zinc).**
- **b. Ceramic-based materials (portland cement, natural pozzolans).**
- **c. Visco-elastic materials (Bitumen).**
- **d. Industrial by-product materials (fly ash, slag, silica fume).**
- **e. Other waste products (C and D waste, crumb rubber).**
- **f. Chemical admixtures for concrete.**
- **g. Fillers for BC.**
- **h. Epoxies and polymers.**
- **i. Fibers and fiber-reinforced polymers.**
- **j. Synthetic aggregates—typically, lightweight and slag aggregates**

3. Composite Manufactured Materials

- **a. PCC.**
- **b. BC.**
- **c. Coated or clad steels**

Advanced materials include the following:

1. **Cementitious Materials.**
   - **a. Performance-specified cements.**
   - **b. Next-generation sustainable cements.**
   - **c. Eco-friendly cements.**
   - **d. Energetically modified cement.**

2. Concrete Materials.

- **a. Engineered cement composites (ECCs).**
- **b. Titanium dioxide–modified concrete.**
- **c. Pervious concrete.**
- **d. Self-consolidating concrete.**
- **e. Sulphur concrete.**
- **f. Autoclaved aerated concrete.**
- **g. Geopolymer concrete.**
- **h. Hydrophobic concrete.**
- **i. Ductile concrete.**

3. Bituminous Binder Materials.

- **a. Sulphur-extended asphalt.**
- **b. Bio-derived asphalt binders.**
- **c. High modified asphalt binders.**

4. Bituminous Materials.

- **a. Warm asphalt mixtures.**
- **b. Perpetual asphalt pavement systems.**
- **c. Porous asphalt pavement.**
- **d. Recycled asphalt shingles.**

5. Metallic and Polymer Materials.

a. Vitreous ceramic coatings for reinforcing steel.

b. Fiber-reinforced polymer bars for CRCPs.

c. Fiber-reinforced polymer dowel bars.

d. Zinc-clad dowel bars.

e. Microcomposite steel for dowels and tie bars.

6. Aggregate Materials.

a. Synthetic aggregates.

b. Manufactured aggregate using captured CO_2.

c. Materials that allow internal concrete curing.

7. Other Materials.

a. Ultra-thin bonded wearing course.

b. Advanced curing material.

c. Workability-retaining admixture.

d. Concrete surface sealers.

SMART MATERIALS

•Smart materials and structures is emerging rapidly with technological innovations in engineering materials, sensors, actuators and image processing.

•Smartness describes self-adaptability, self-sensing, memory and multiple functionalities of the materials or structures.

•These characteristics provide numerous possible applications for these materials and structures in aerospace, manufacturing, civil infrastructure systems and biomechanics.

•Self-adaptation characteristics of smart structures are a great benefit that utilizes the embedded adaptation of smart materials like shape memory alloys.

•By changing their properties, smart materials can detect faults and cracks and therefore are useful as a diagnostic tool.

•This characteristic can be utilized to activate the smart material embedded in the host material in a proper way to compensate for the fault. This phenomenon is called self-repairing effect.

INDUSTRIAL WASTE IN HIGHWAY CONSTRUCTION

DEVELOPMENT OF ALTERNATIVE MATERIALS

- Good quality aggregates are depleting and cost of material extraction is increasing, researchers are looking for suitable alternative materials.
- The tests and specifications, which are applicable for conventional materials, may be inappropriate for evaluation of non-conventional materials (i.e. alternative materials).
- This is because the material properties, for example, particle sizes, grading and chemical structure, may differ substantially from those of the conventional materials.
- Thus, for an appropriate assessment of these materials, new tests are to be devised and new acceptability criteria are to be formed.

DEVELOPMENT OF ALTERNATIVE MATERIALS

- However, with the advent of performance-based tests, it is expected that the performances of the conventional as well as new materials can be tested on a same set-up and be compared.
- Industrial and domestic waste products provide a prospective source of alternative materials.
- These materials are cheaply available.
- Also, their use in road construction provides an efficient solution to the associated problems of pollution and disposal of these wastes.

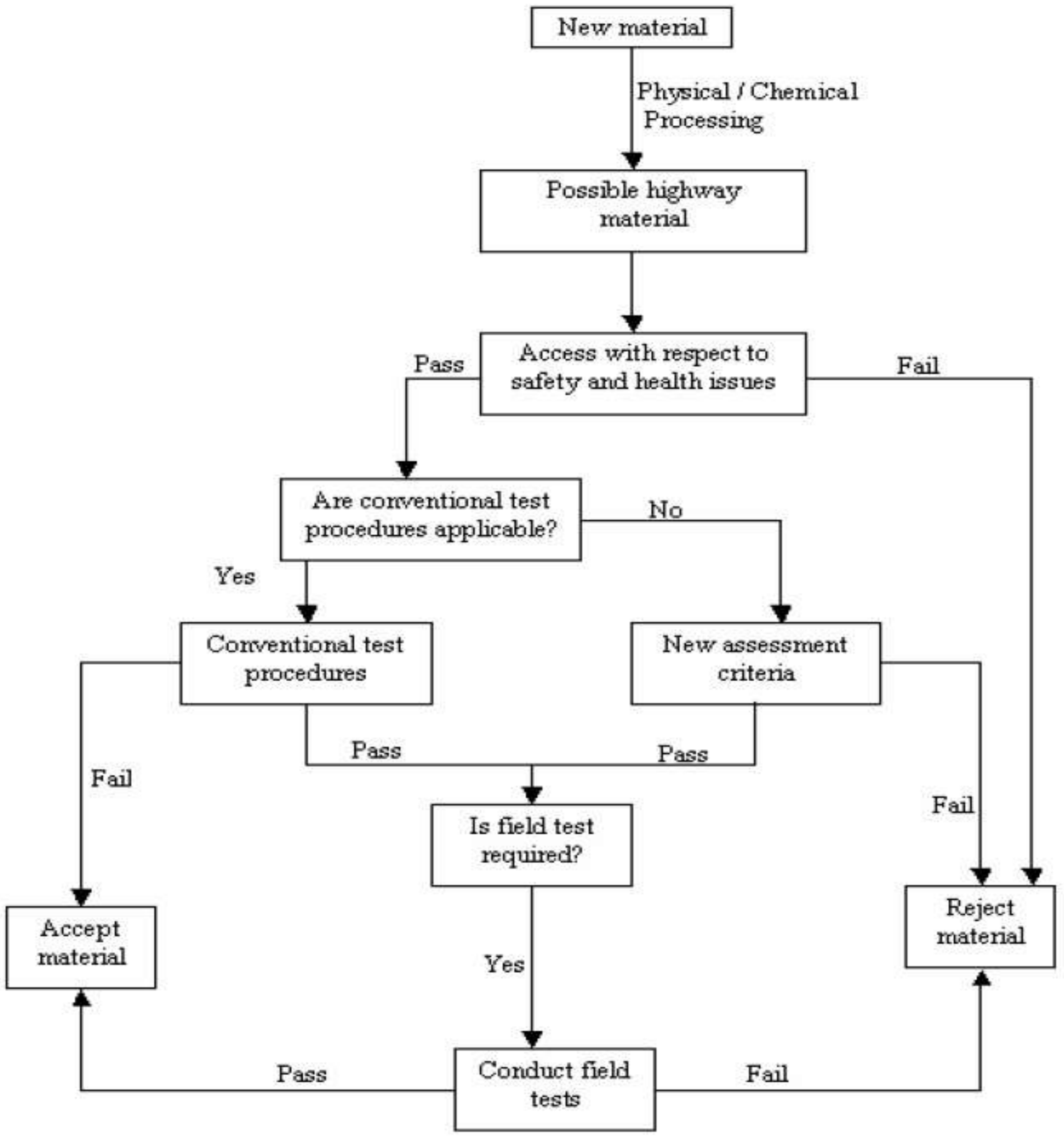
Possible usage of industrial waste products in highway construction

Waste product	Source	Possible usage
Fly ash	Thermal power station	Bulk fill, filler in bituminous mix, artificial aggregates
Blast furnace slag	Steel industry	Base/ Sub-base material, Binder in soil stabilization (ground slag)
Construction and demolition waste	Construction industry	Base/ Sub-base material, bulk-fill, recycling
Colliery spoil	Coal mining	Bulk-fill
Spent oil shale	Petrochemical industry	Bulk-fill
Foundry sands	Foundry industry	Bulk-fill, filler for concrete, crack-relief layer
Mill tailings	Mineral processing industry	Granular base/sub-base, aggregates in bituminous mix, bulk fill
Cement kiln dust	Cement industry	Stabilization of base, binder in bituminous mix
Used engine oil	Automobile industry	Air entraining of concrete
Marble dust	Marble industry	Filler in bituminous mix
Waste tyres	Automobile industry	Rubber modfied bitumen, aggregate
Glass waste	Glass industry	Glass-fibre reinforcement, bulk fill
Nonferrous slags	Mineral processing industry	Bulk-fill, aggregates in bituminous mix
China clay	Bricks and tile industry	Bulk-fill, aggregates in bituminous mix

Suitability of using industrial waste products in highway construction

Material	Advantages	Disadvantages
Fly ash	Lightweight, used as binder in stabilized base/ sub-base due to pozzolanic properties	Lack of homogeneity, presence of sulphates, slow strength development
Metallic slag - Steel slag - Nonferrous slag	Higher skid resistance Light weight (phosphorus slag)	Unsuitable for concrete and fill work beneath slabs. May show inconsistent properties
C & D Waste	More strength, can be used as aggregates granular base	May show inconsistent properties
Blast furnace slag	Used in production of cement, granular fill	Ground water pollution due to leachate formation, used as unbound aggregates
Colliery spoil	-	Combustion of unburnt coal, sulphate attack in case of concrete roads
Spent oil shale	-	Burning of combustible materials
Foundry sands	Substitute for fine aggregate in bituminous mixes	Presence of heavy metals in non ferrous foundry origin, less affinity to bitumen
Mill tailings	Some are pozzolanic in nature	Presence of poisonous materials (e.g., cyanide from gold extraction)
Cement kiln dust	Hardens when exposed to moisture, can be used in soil stabilization	Corrosion of metals (used in concrete roads) in contact because of significant alkali percentage
Used engine oil	Good air entertainer, can be used in concrete works	Requires well organized used oil collection system
Rubber tires	Enhances fatigue life	Requires special techniques for fine grinding and mixing with bitumen, sometimes segregation occurs

Evaluation industrial waste for suitability in highway construction



Laboratory Results of C & D Waste

Description of material	Specific Gravity	Water absorption (%)	Aggregate crushing value (%)	Aggregate impact value(%)	Los angeles abration value (%)
Crushed concrete (fresh)	2.64	2.71	33.2	26.5	28.7
Crushed concrete (20 yrs old)	2.51	4.54	34.8	29.3	30.5
Stone masonry (fresh)	2.42	4.93	38.4	31.7	36.3
Stone masonry (20 yrs old)	2.28	6.82	42.7	33.5	38.9
Brick masonry	2.10	10.36	65.3	59.3	72.4
Conventional aggregate	2.73	0.45	24.2	20.7	19.8


THANK YOU